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344,907 28 April 1989 (28.04.89) US
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(71)(72) Applicant and Inventor: ABRAHAM, Karoly, Charles [HU/US]; 8101 Midnight Pass Road, Sarasota, FL 34242-2723 (US).

(74) Agent: FIELDS, Scott, J.; Ferrill and Logan, C-13, Executive Mews, 2300 Computer Avenue, Willow Grove, PA 19090 (US).

(81) Designated States: AT (European patent), AU, BE (European patent), CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), HU, IT (European patent), JP, LU (European patent), NL (European patent), SE (European patent), SU.

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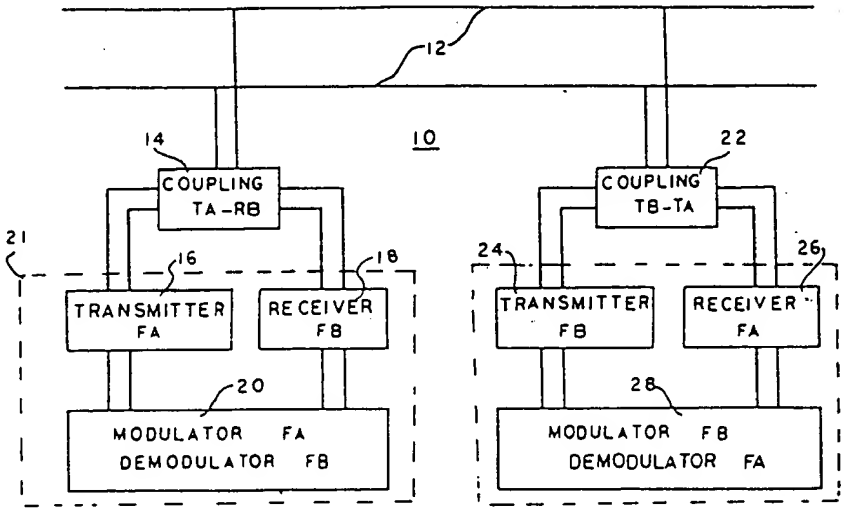
(54) Title: POWER-LINE COMMUNICATION APPARATUS



(57) Abstract

Apparatus for power system communications includes a coupler (14) at each of two or more locations along a pair of power-lines, the coupler having a pair of serial LC circuits with an air coil. A transmitter (FA), a receiver (FB), and a modem (20) is also provided at each of the locations such that each of the LC circuits of the couplers (14) resonate at a given frequency. The apparatus incorporate novel non-linear transformers which eliminate the signal from the power line and its harmonics, and which permit rapid transmission of signals for communications and other uses.

+ See back of page

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DK	Denmark	LU	Luxembourg	TG	Togo
				US	United States of America

INTERNATIONAL SEARCH REPORT

International Application No PCT/US90/02291

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC [5] H04B 1/50 H04L 5/14
U.S.CL. 370/30 340/310R

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System	Classification Symbols
U.S.CL.	370/24,27,28,30 340/310R,310A

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched [5]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
Y	US, A, 4,058,678 (DUNN ET AL) 15 November 1977 See col. 6, line 32 - col. 11, line 3.	1,3,8-11,13-15, 17,18,24
A	US, A, 4,885,563 (JOHNSON ET AL) 05 December 1989	

* Special categories of cited documents: [15]

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search [2]	Date of Mailing of this International Search Report [2]
17 OCTOBER 1990	05 FEB 1991
International Searching Authority [1]	Signature of Authorized Officer [20]
ISA/US	WELLINGTON CHIN

- 1- *-

H04B3/56 RY

EUROPEAN SEARCH REPORT

Application Number

EP 90 90 7855

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	EP-A-0 115 814 (SIEMENS AG.) * page 2, line 19 - page 3, line 36; figures *	1,12,14, 15	H04B1/50 H04L5/14
A	EP-A-0 156 557 (CONTROLONICS CORP.) * page 4, line 13 - line 26 *	1,12,14, 15,23,24	
A	PATENT ABSTRACTS OF JAPAN vol. 10, no. 283 (E-440)(2339) 26 September 1986 & JP-A-61 102 009 (TAKEISHI IKEDA) 20 May 1986 * abstract *	1,14,15, 29	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

H04B
H01F

The supplementary search report has been drawn up for the claims attached hereto.

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 APRIL 1992	BOSSEN M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P0401)

What is claimed is:

1. Power line communication apparatus comprising;

modulator means for modulating a carrier signal having a first frequency;

transmitter means coupled to said modulator means for transmitting said modulated carrier signal having said first frequency to coupler means and;

coupler means comprising capacitor means electrically connected to a power line and air-core transformer means coupled to said transmitter means, said transformer means transmitting said modulated carrier signal having said first frequency through said capacitor means and over said power line.

2. The power line communication apparatus of claim 1 wherein said transformer means comprises a primary coil having a first diameter, said primary coil being coupled to said capacitor means, and a secondary coil having a second smaller diameter, said secondary coil extending coaxially within said primary coil such that an air gap is created between said primary and said secondary coils.

3. The power line communication apparatus of claim 1 wherein said air-core transformer functions as a capacitively coupled transformer, having a capacitor between the primary and secondary coils of the transformer.

4. The power line communication apparatus of claim 1 further comprising second coupler means comprising second capacitor means and second air-coil transformer means for receiving carrier signals having a second frequency over a power line;

receiver means connected to said coupler means for receiving said carrier signals having a second frequency from said coupler means;

and demodulator means for processing said carrier signal having a second frequency received from said receiver means.

5. The communications apparatus according to claim 2 wherein the ratio of the number of turns of said primary to secondary coils is about one to one.

6. The communications apparatus according to claim 2 wherein a static capacitance is created between the primary and

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21 JUN 1991

secondary windings of said coils which function as a high-pass filter with the secondary windings.

7. The power line communication means of claim 4 wherein said second air-coil transformer means comprises a primary coil having a first diameter, said primary coil being coupled to said capacitor means and a secondary coil having a second smaller diameter, said second coil extending coaxially within said primary coil such that an air gap is created between said primary and said secondary coils.

8. The communication apparatus according to claim 1, wherein said first frequency is less than about 1 Megahertz.

9. The communication apparatus according to claim 1, wherein said first frequency that is less than about 160 kilohertz.

10. The communication apparatus according to claim 1, wherein said first frequency comprises a power level of about twenty decibels above any other frequency.

11. The communication apparatus according to claim 2 wherein said air-coil transformer means comprises impedance matching means such that the primary coil resistivity for transmission and reception at carrier frequency is about equal to the input impedance of the power line.

12. The communications apparatus according to claim 1, wherein said coupler means resonates at said first carrier frequency.

13. The power line communication apparatus of claim 1 wherein said transmitter means simultaneously transmits at least a second carrier signal having a second frequency through said coupler means.

14. Power line communication apparatus comprising;

modem means for transmitting first carrier signals having a first frequency over a power line for receiving second carrier signals having a second frequency from a power line; and

coupler means connected between said modem means and said power line, said coupler means including air-coil transformer means for transmitting or receiving said first and second carrier signals over said power line.

15. Communication apparatus for a pair of power-lines,

comprising:

first coupling means, including a pair of serial LC circuits, coupled to the pair of power-lines;

first transmitter means, coupled to said first coupling means, for transmitting signals carried by a first carrier frequency across the pair of power-lines;

first receiver means, coupled to said first coupling means, for receiving signals carried by a second carrier frequency from the pair of power-lines;

first modem means, coupled between said first transmitter means and said first receiver means, for modulating said signals to be carried by said first carrier frequency and for demodulating said signals carried by said second carrier frequency;

second coupling means, including a pair of serial LC elements, coupled to the pair of power-lines;

second transmitter means, coupled to said second coupling means, for transmitting said signals to be carried by said second carrier frequency across the pair of power-lines;

second receiver means, coupled to said second coupling means, for receiving said signals carried by said first carrier frequency from the pair of power-lines; and

second modem means, coupled between said second transmitter means and said second receiver means, for modulating said signals to be carried by said second carrier frequency and for demodulating said signals carried by said first carrier frequency.

16. The duplexing apparatus according to claim 15, wherein one of said serial LC circuits of both of said first and second coupling means comprises a first plurality of capacitors and a first air coil including primary and secondary windings, the diameter of said primary winding being greater than the diameter of said secondary winding thereby creating an air coil between said primary and secondary windings, while the other serial LC circuit comprises a second plurality of capacitors and a second air coil including primary and secondary windings, the diameter of said primary winding being greater than the diameter of said secondary winding thereby creating an air core between said

primary and secondary windings, wherein said first plurality of capacitors are connected together in parallel between one of the power-lines and said primary winding of said first air coil, said primary winding of said first air coil thereafter being serially connected to the other power-line, and said secondary winding of said first air coil is connected to its respective transmitter means, and wherein said second plurality of capacitors are serially connected together between said one of the power-lines and said primary winding of said second air coil, said primary winding of said second air coil thereafter serially connected to the other power-line.

17. The communications apparatus according to claim 15, wherein said first and second coupling means each have a bandwidth of less than about 500 kilohertz.

18. The communications apparatus according to claim 15, wherein said first and second coupling means each have a bandwidth of less than about 100 kilohertz.

19. The communications apparatus according to claim 15 wherein the primary and secondary windings of said first and second air coils function as a phase shift non-linear transformer.

20. The communications apparatus according to claim 15 wherein the primary and secondary windings of said first and second air coils function as a capacitively coupled transformer.

21. The communications apparatus according to claim 15 wherein the ratio of the number of turns of said primary to secondary coil in said first air coil means is about one to one.

22. The communications apparatus according to claim 15 wherein the ratio of the number of turns of said primary to secondary coil in said second air coil means is about one to one.

23. The communications apparatus according to claim 15 wherein the created capacitance created between the primary and secondary windings of said air coils function as a high-pass filter with the secondary windings.

24. The communications apparatus according to claim 15 wherein the primary windings with the plurality of capacitors function as a band-pass filter.

25. The communications apparatus according to claim 15

wherein said first plurality of capacitors includes resistor means to evenly divide down the voltage over said first plurality of capacitors.

26. The communication apparatus according to claim 25 wherein said second plurality of capacitors includes resistor means to evenly divide down the voltage over said second plurality of capacitors.

27. The communication apparatus according to claim 25 wherein said first plurality of capacitors resonates with the primary winding of said first air coil.

28. The communication apparatus according to claim 25 wherein said second plurality of capacitors resonates with the primary winding of said first air coil.

29. In a power line communication apparatus, an improved coupler comprising capacitor means coupled to a power line and air-core transformer means comprising a primary coil having a first diameter, said primary coil being coupled to said capacitor means, and a secondary coil extending coaxially within said primary coil such that an air gap is created between said primary and secondary coils.

CORRECTED VERSION *

PCT

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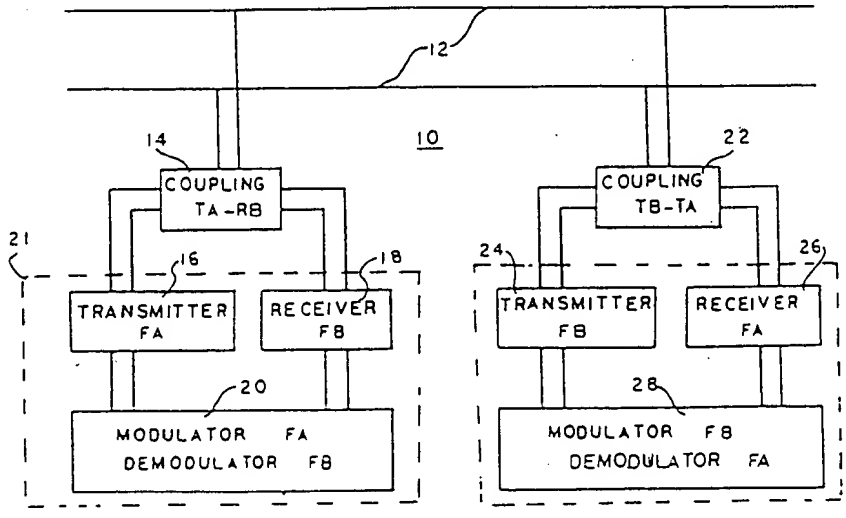

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